

The Impact of Bottom Roughness and Bioturbation Intensity on Benthic Optical Properties

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LONG-TERM GOALS

The ultimate objective of this research program is to identify and obtain a predictive understanding of the physical and biological processes responsible for the formation and maintenance of the microtopography (decimeter to millimeter) of the sea floor. To achieve this goal, it is necessary to study formative processes occurring on the sediment surface (e.g., biogenic mound formation, ripple development), as well as processes occurring within the seabed (e.g., bioturbation, compaction) which generally lessen microtopography. The approach to this area of interest is predominantly field-oriented, with a secondary emphasis on model development.

OBJECTIVES

The primary goal of this project, which is part of the Coastal Benthic Optical Properties (CoBOP) DRI, is the quantification of bottom roughness along transects extending from open sand flats to coral reefs near Lee Stocking Island (LSI), Bahamas. Specific questions include: (1) What is the sediment bottom roughness? (2) Does sediment bottom roughness vary spatially in a predictable manner (e.g., away from the coral reef)?, (3) Does sediment bottom roughness vary significantly in time?, and (4) What is the relationship between sediment bottom roughness and bioturbation intensity?

APPROACH

Measurements of bottom roughness are made either using a 35-mm PhotoSea 2000 metric stereocamera (Wheatcroft, 1994) mounted on a neutrally-buoyant, diver-manipulatable vehicle ("survey") or using a similar stereocamera mounted on a tripod ("time-lapse"). Following standard film development, the images are digitized at a high resolution (i.e., > 4000 pixels/inch) by a third-party aerial mapping firm and stored on CD-ROMs. Sea floor height information is obtained from analytically rectified digital stereo-images using matching algorithms. Jonathan Howland of the Deep Submergence Lab at WHOI conducts the latter.

Independent, co-located measurements of sediment bioturbation intensity and mode are made during the field studies. The bioturbation measurements involve the spreading of glass beads onto a patch of sea floor, followed by tube coring and vertical sectioning after periods of days to a month. Tracers are enumerated by dissolving the ambient, carbonate grains.

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WORK COMPLETED

The camera vehicle was tested in Monterrey during November 1997 and then used, along with the time-lapse system, at LSI in May 1998. Activities at LSI included deployment of the time-lapse stereocamera adjacent (within 2 meters) to the N. Perry reef for a period of 12 days. Bottom stereophotographs were taken every 23 minutes for two days, and then every 6 hours for the remainder of the deployment, thereby providing rate information over a range of time scales. Second, the camera vehicle was “flown” along an 80-m, reef-normal transect line on two separate occasions, thereby providing spatial data. Third, a series of deliberate tracer bioturbation experiments were conducted at sites next to, and far from the reef. All of these activities were successful (i.e., the equipment worked and the experiments were completed).

RESULTS

At this time, the primary quantitative result has been a demonstration that the bottom roughness measurement protocol is accurate (e.g., ~2 mm mean error at an altitude of 1500 mm). Analysis of the time-lapse and survey photographs is therefore proceeding. Several qualitative observations, however, can be made from the raw images. Bottom roughness at the N. Perry site is controlled mainly by biological reworking of the sediment. Both mound-building and surface deposit feeding infauna, as well as demersal fish (e.g., goatfish) rapidly alters the sediment microtopography. Prior to the LSI campaign there was a major physical sediment transport event that created wave ripples roughly 12 cm high with 50-cm wavelengths. The time-lapse data clearly showed that these ripples were in the process of being destroyed by biological reworking. The transect images suggest that biological roughness is in fact different (perhaps greater) close to the reef, as opposed to 80 meters away from the reef. As a result, the wave ripples were more pronounced and readily recognizable away from the reef, even though the water depth was greater (i.e., bottom stress would be less). In addition, a greater fraction of the sediment surface was covered by epibenthic microalgae as one moved further from the reef.

IMPACT/APPLICATIONS

The development of a photographic system capable of quantifying sea floor microtopography is likely to have widespread application in marine geology. For example, studies of sediment transport and acoustical interactions with the sea bottom would both benefit from knowledge of the short-term evolution of bottom roughness.

TRANSITIONS

No transitions are currently known, however, researchers at the Naval Research Laboratory (Stennis) are potential users of the stereomatching algorithm.

RELATED PROJECTS

Discussions have been initiated with Drs. Larry Brand and Charlie Mazel regarding the epibenthic diatoms observed at the N. Perry site. During LSI-2 (May 1999) dedicated measurements will be made to examine processes that control the small-scale distribution of the diatoms.

REFERENCES

Wheatcroft, R.A. 1994. Temporal variation in bed configuration and one-dimensional bottom roughness at the mid-shelf STRESS site. *Continental Shelf Research*, 14: 1167-1190.